

Remarks

Applicant acknowledges the restriction requirement made by the Examiner and notes that the claim cancellations above serve to elect Group II, claims 25-50. Therefore, claims 25-50 remain pending. Claims 1-24 and 51-70 have been canceled above, consistent with current amendment practice. Figures 4 and 5 have been amended on replacement sheets, provided herewith, in a manner that is consistent with the Examiner's comments. Applicant appreciates the Examiner's review of the Application.

The Rejections Under 35 U.S.C. § 102

The Examiner rejected claims 25, 28, 29, 31-34, 38, 39 and 48-50 under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent no.5,230,387 issued to Waters et al (hereinafter Waters). Applicant respectfully disagrees at least for the reasons set forth below.

Referring to Waters, his overall purpose is described at column 10, lines 1-10:

The focus of this invention, however, is the use of magnetic and gravity fields to determine the orientation and path of the borehole with respect to the earth and the orientation of the tool within the borehole, and to combine this information with information about drill-string dynamics and with the formation evaluation measurements made concurrently by the conductivity, resistivity and radioactivity or other sensors and to transmit the data while drilling to the surface for calculations, readout, and the use by surface personnel. The tool can also be used to determine while drilling range and direction to a subterranean target which exhibits or may be induced to exhibit a magnetic field.

In this context, Waters generally teaches a measurement while drilling (MWD) system which is downhole and is also configured for performing borehole logging. As will be further discussed, Waters teaches the determination of a distance to some sort of underground magnetic formation from a current position of the downhole assembly. With this framework in mind, Applicants will address the details of the claims immediately hereinafter, as contrasted with the teachings of Waters.

Initially considering independent claim 25, it should be appreciated that a boring tool is required which transmits an electromagnetic locating signal. While the original limitations of claim 25 already require reception of the locating signal within a dipole range, the claim has been amended to recite that the electromagnetic field is characterized by a dipole field. In attempting to meet these limitations, the Examiner refers to column 12, line 34 and column 20, lines 53-55 of Waters. With respect to the former cited passage, Applicant first notes that this passage merely refers to magnetic sensors (i.e., magnetometers) as opposed to electromagnetic field sensors. It should be appreciated that a magnetometer can be sensitive to both static magnetic fields and electromagnetic fields which can be time varying. An electromagnetic sensor, however, can not detect a static magnetic field such as the Earth's magnetic field. Thus, the use of a magnetometer is preferred in Waters, since anomalies in the Earth's magnetic field can be created by "Large pieces of magnetic material", as described at column 11, lines 43-50. Waters is interested in local, static effects produced in the Earth's static magnetic field. Applicant does not believe that it is reasonable to characterize a magnetic anomaly, as taught by Waters, as an electromagnetic locating signal. Accordingly, it is believed that Waters fails to teach, disclose or reasonably suggest the use of an electromagnetic locating field.

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Still considering column 12 of Waters, the use of two magnetometers, which are spaced apart by a fixed distance, is described. Both magnetometers are located in the downhole assembly. Apparently, the Examiner is asserting that these magnetometers are the detectors required by claim 25. Applicant respectfully disagrees. Column 12 clearly describes the use of these magnetometers to determine an average value of the magnetic field with the overall downhole assembly located at a first position. The downhole assembly is then moved to a second position, in a very specific way, at which a second average value of the magnetic field is determined. Using these two average values, the distance from the downhole assembly to the magnetic anomaly is then determined. It should be appreciated, in this regard, that the Waters technique is limited to a radial path headed straight toward the anomaly, as illustrated in Figure 3 of Waters and described at column 11, line 67. What is determined is a relative radial distance to the anomaly from a current position of the downhole assembly. Claim 25, in contrast, recites determining absolute positions of the detectors in the region using the first and second sets of electromagnetic data. The purpose is to identify the absolute positions of the detectors, as described on page 7, lines 7-10 of Applicant's disclosure. It should be appreciated that this is completely different from merely determining a relative distance between a pair of magnetic detectors and some form of magnetic anomaly.

As another distinction, it is important to note that, with respect to the use of a dipole field, Waters states:

For example, a magnetized elongated structure forming a magnetic dipole will have magnetic flux lines emanating from one end to the other. However, if the structure is sufficiently long and the point of observation is moved proximate one end, the magnetic body will appear to be one single pole, body with outwardly, radially directed flux lines extending from the elongate magnetic structure. In practice, most situations reduced to these monopole configurations emanating from pipe collars or other imperfections.

Figures 4 and 5 of Waters, described at column 14, lines 32-38, specifically illustrates substitution of a purely radial or monopole static magnetic field for a static dipole field. Clearly, Waters teaches away from any need to use a dipole field by characterizing or reducing the dipole field to a monopole field in practice. The Waters technique requires the use of radial varying monopole magnetic fields. Such a simplification is unacceptable for purposes of the present invention. That is, characterization of the dipole field required by claim 25 as a monopole field would render the recited method as inoperable. Further, Applicant finds no mention of dipole range in Waters, as suggested by the Examiner. Accordingly, it is considered that Waters teaches away from the limitations of claim 25 wherein the use of a dipole field and dipole range are required. For these reasons, standing on their own, it is submitted that the rejection of claim 25 over Waters should be withdrawn. Still further compelling reasons are considered to favor the patentability of claim 25 over the art of record, as will be discussed immediately hereinafter.

Attention is now directed to the passage cited by the Examiner which appears in column 20 of Waters. Specifically, column 20, lines 53-55 of Waters states:

With the addition of electromagnetic: [sic] transmitters and receivers to the tool having spaced receiver antennas, at known and constant distances from the transmitting antennas, the formation can be logged by propagating electromagnetic waves and measuring or inferring the resistivity from difference in phase between the two signals at the receiving antennas. [emphasis supplied]

Waters is merely describing borehole logging using an electromagnetic signal. Borehole logging is used to measure characteristics of the material surrounding the borehole and along its length, for example, in searching for hydrocarbons (see Waters column 21, line 6). The use of borehole logging is submitted to bear no reasonable relationship to the use of an electromagnetic locating signal with above ground detectors, as recited by claim 25. In support of this position, the Waters transmitter and receivers are co-located in the downhole assembly. Measurements made with this configuration rely entirely on a fixed positional relationship between the transmitter and the receivers. There is no need to identify the position of the transmitter with respect to the receivers since it is necessarily known and can not change. Therefore, Applicant considers that Waters, taken in any reasonable light, fails to teach, disclose or suggest an electromagnetic locating signal. It is respectfully submitted that any reliance on this passage by the rejection under discussion takes this passage improperly out of context and should be withdrawn for this reason standing on its own.

For all of the foregoing reasons, it is submitted that claim 24, as amended, is patentable over Waters. Hence, allowance of claim 25 is respectfully requested.

Claims 28, 29, 31-34, 38 and 39 each depend either directly or indirectly from and therefore include the limitations of amended claim 25. Accordingly, it is respectfully submitted that each of these claims is also patentable over the art of record for at least the reasons set forth above with respect to claim 25. Further, each of these dependent claims places additional limitations on their parent and intermediate claims which, when considered in light of claim 25, further distinguish the claimed invention from the art of record.

For example, claim 28 recites that the electromagnetic locating signal includes a known signal strength which forms part of the certain information. Inasmuch as Applicants consider that Waters fails, in the first instance, to teach the use of an electromagnetic locating signal, Waters certainly could not teach the use of such signal having a known signal strength.

As another example, claim 29 recites measuring a distance between the first and second positions of the boring tool and, thereafter, using this distance as part of the certain information in a way which improves accuracy in determining the absolute positions of the detectors in the region. As discussed above, the only positional determination made by Waters is a relative, as opposed to absolute, position. Further, this distance is used, as recited, to improve accuracy in determination of the absolute positions of the detectors. Applicant is unable to find a reasonably related teaching in Waters.

As still another example, claim 31 recites that receiving the electromagnetic locating signal further includes producing one or more additional subsets of electromagnetic data at one or more additional positions of the boring tool. These additional subsets of electromagnetic data are then used in determining the absolute positions of the detectors as part of the overall electromagnetic data. Claim 32 further requires that the determination of the absolute positions of the detectors includes an overall certain number of known values and an overall certain number of unknown values and that the measurements taken at the second position and at each additional position of the boring tool contribute at least one more additional known value to the overall certain number of known values such that the number of overall certain number of known values can be increased relative to the overall number of unknown values. Claim 33 still further recites that measurements are taken at a sufficient number of positions such that the overall certain number of known values is

equal to or greater than the overall certain number of unknown values so as to use only electromagnetic data in determining the absolute positions of the detectors. Applicant finds nothing in Waters with respect to these various combinations of limitations.

Claim 34 depends directly from claim 32 and recites that the determination of the absolute positions of the detectors includes using the additional known values in place of at least portions of the certain information.

Claim 38 depends directly from claim 25 and requires a number of detailed limitations. In particular, the boring tool is moved to a third position and the absolute position and orientation of the boring tool is established at the third position using the detectors at their initial positions. The detectors are then moved to new positions or additional detectors are provided at the new positions. The electromagnetic locating signal is received using the detectors at the new positions with the boring tool at the third position to produce a first subsequent set of electromagnetic data. The boring tool is then moved to a fourth position. The electromagnetic locating signal is received using the detectors at the new positions with the boring tool at the fourth position to produce a second subsequent set of electromagnetic data. Using certain information, including the first and second subsequent sets of electromagnetic data, absolute positions of the detectors at the new positions are determined within the region. In this way, a series of absolute positions of the detectors and the boring tool are determined within the region. Claim 39 further recites that the detectors at the new positions are farther from the start position of the boring tool than at their initial locations such that the boring tool is locatable for a distance beyond the dipole range from the start position of the boring tool. Accordingly, drilling range is extended to beyond the dipole range in a highly advantageous light. It is considered that Waters, when viewed in any reasonable light, is devoid of this combination of features. Hence, allowance of these claims over the art of record is respectfully requested.

Claims 48-50 are dependent claims which depend directly or indirectly from dependent claim 41 which itself depends from independent claim 40. It is noted that claims 40 and 41 were rejected under 35 U.S.C. § 103, as discussed below. Hence, it is considered that the Examiner meant to reject claims 48-50 only under § 103, as well. Accordingly, claims 48-50 will be addressed subsequent to the discussion of claims 40 and 41.

The Rejections Under 35 U.S.C. § 103

The Examiner rejected claims 40, 41 and 48-50 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 4,881,083, issued to Chau et al. (hereinafter Chau) in view of Waters. Applicant respectfully disagrees at least for the reasons set forth below.

The Examiner relies on Chau for teaching a directional drilling system, but admits that Chau fails to disclose two detectors. Applicant initially notes that this characterization of Chau sweeps too broadly. The Chau reference teaches a homing system in which the boring tool homes in to a receiving antenna or some position that is associated with the receiving antenna. Hence, Chau uses a single detector. The suggestion that this reference can be modified to include two detectors is considered by Applicant to be unreasonable and would result in an overall configuration that is not suited for its intended purpose or that is inoperable in the absence of extensive additional teachings with regard to performing this modification.

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With respect to Waters, the Examiner merely asserts that Waters teaches two detectors. Applicant, however, points out that claim 40 requires that one of the detectors includes transmitter means for transmitting a relative locating signal to a second detector in a setup mode such that the second detector receives the relative locating signal. The position of the second detector is then determined relative to the first detector based on the received relative locating signal. Applicant is unable to find any reasonable teaching, disclosure or suggestion in Waters with respect to this combination. Clearly, the mere teaching of a pair of spaced apart magnetometers, as what is fairly taught by Waters, fails to meet these combined limitations. Moreover, it is submitted that there is no relevant teaching in Chau with respect to these limitations. For at least these reasons, allowance of claim 40 is respectfully requested.

Claims 41 and 48-50 each depend either directly or indirectly from and therefore include the limitations of amended claim 40. Accordingly, it is respectfully submitted that each of these claims is also patentable over the art of record for at least the reasons set forth above with respect to claim 40. Further, each of these dependent claims places additional limitations on their parent and intermediate claims which, when considered in light of claim 40, further distinguish the claimed invention from the art of record.

For example, claim 41 recites establishing initial absolute positions of the detectors and the boring tool within the region using certain information including the electromagnetic data in conjunction with the relative position established between the detectors. In this regard, Applicant finds no teaching in the art of record with respect to determination of a relative detector-to-detector position, as claimed, or its subsequent use.

As another example, claim 48 depends from claim 41 and includes certain limitations discussed above, for example, with respect to independent claim 25. For example, at least two detectors are required. As another example, absolute positions of the detectors are determined using first and second sets of electromagnetic data. Accordingly, it is considered that the arguments made above with respect to the patentability of claim 25 are equally applicable with respect to these limitations. Moreover, the relative position established between the detectors is used in conjunction with the first and second sets of electromagnetic data to determine the absolute detector positions. Accordingly, for at least these reasons, allowance of claim 48 is respectfully requested.

Claim 49 depends directly from claim 41 and includes all of the limitations of claim 48. Hence, it is submitted that claim 48 is also allowable for at least the reasons given with respect to claim 48. Further, claim 49 recites that a distance between the first and second positions of the boring tool is established through extending the drill string and that this distance is used in conjunction with the electromagnetic data and the relative position between the detectors. Claim 50 further recites that one or more additional subsets of electromagnetic data are produced at one or more additional positions of the boring tool, and the additional subsets of electromagnetic data, thereafter, are used as part of the overall electromagnetic data in a way which improves accuracy in determining the absolute positions of the detectors and the boring tool in the region. Applicant is unable to find any reasonable teaching, disclosure or suggestion of this combination of features in the art of record.

The Examiner rejected claims 26, 27 and 35-37 under 35 U.S.C. § 103(a) as being unpatentable over Waters in view of U.S. Patent No. 4,812,812, issued to Flowerdew et al (hereinafter Flowerdew). Applicant respectfully disagrees. Initially is noted that each of these claims depends either directly or indirectly from and therefore includes the limitations

of amended claim 25. Accordingly, it is respectfully submitted that each of these claims is also patentable over the art of record for at least the reasons set forth above with respect to claim 25 and with respect to any intermediate dependent claims. Moreover, it is submitted that Flowerdew lends nothing to the rejections of claim 25 and these intermediate dependent claims under § 102 in any reasonable combination with Flowerdew. Further, each of these dependent claims places additional limitations on their parent and intermediate claims which, when considered in light of claim 25, further distinguish the claimed invention from the art of record.

Considering the combination of Waters and Flowerdew, it is submitted that the combination is not reasonable. Specifically, Flowerdew teaches an above ground transmitter with a single receiver in the boring tool. Waters uses a downhole assembly which, as discussed above, fails to teach the use of an electromagnetic locating signal. Further, Waters fails to teach two above ground detectors for receiving the locating signal. Seen in this light, it is clear that any number of complex modifications, considered as well beyond the capability of those having ordinary skill in the art, would be necessary to complete the proposed modification of Waters' downhole assembly to include the Flowerdew transmitter and two above ground detectors. For at least these reasons, Applicant would have no motivation to modify the downhole assembly of Waters to include the transmitter of Flowerdew. In this regard, a combination under § 103 is improper unless the prior art itself provides an objective teaching of the proposed modification of the references. Applicant respectfully submits that these teachings are missing and that the suggested combination is unreasonable, for all of the foregoing reasons, and that the rejections of claims 26, 27 and 35-37 over this combination should be withdrawn.

Further considering claim 26, this claim recites that the tilt orientation of each detector forms part of the certain information. The Examiner relies on Flowerdew as assertedly measuring pitch of the boring tool. It is noted that the tilt of the detectors is being measured, as claimed, not the boring tool tilt and that this tilt information is used along with the electromagnetic data.

As another example, claim 27 recites that the boring tool includes a pitch sensor such that the pitch angle of the boring tool is used along with the electromagnetic information. In this regard, column 5, lines 13-20, Flowerdew states:

By comparing the signals on each axis, which must still follow mathematically predictable relationships, it is possible to establish by use of all three axes of transmission not only roll, pitch and yaw... [emphasis supplied]

Applicant submits that a mere suggestion of what is possible falls considerably short of an enabling disclosure and, thus, renders Flowerdew as defective with respect to objectively teaching pitch measurement. Hence, allowance of claim 27 is respectfully requested.

As yet another example, claim 35 recites that the detectors include a tilt orientation and the determination of the absolute positions of the detectors considers the tilt orientation of each detector as an unknown value. That is, tilt is not measured but is considered as an unknown value, yet the absolute position of each detector is determined. Applicants are unable to find any reasonable teaching with respect to this limitation in the art of record.

As a continuing example, claim 36 recites that the boring tool includes a pitch orientation and wherein the determination of the absolute positions of said detectors includes using the additional known values instead of using a

measured value of the pitch such that the pitch orientation forms part of the certain number of unknown values. Claim 37 depends directly from claim 36 and recites that the electromagnetic locating signal includes a signal strength and that the determination of the absolute positions of the detectors includes using the additional known values, instead of using an assumed value of the signal strength, such that the signal strength forms one of the unknown values. Applicants are unable to find any reasonable teaching with respect to these limitations in the art of record.

The Examiner rejected claim 30 under 35 U.S.C. § 103(a) as being unpatentable over Waters in view of U.S. Patent No. 3,725,777 issued to Robinson et al (hereinafter Robinson). Applicant respectfully disagrees. Initially is noted that claim 30 depends directly from and therefore include the limitations of amended claim 25. Accordingly, it is respectfully submitted that claim 30 is also patentable over the art of record for at least the reasons set forth above with respect to claim 25. Moreover, it is submitted that Robinson lends nothing to the rejections of claim 25 under § 102 in any reasonable combination with Waters. Further, claim 30 places additional limitations on claim 25 which further distinguish the claimed invention from the art of record. For example, claim 30 requires that distance is used in a way which overdetermines the absolute receiver positions. Applicant finds no mention of these limitations in the rejections at hand nor any reasonably related teaching in the art of record. Accordingly, allowance of claim 30 is respectfully requested.

The Examiner rejected claims 42-47 under 35 U.S.C. § 103(a) as being unpatentable over Chau in view of Waters as applied to claim 41 and further in view of Flowerdew. Applicant respectfully disagrees. Initially is noted that each of these claims depends either directly or indirectly from and therefore includes the limitations of amended claim 40. Accordingly, it is respectfully submitted that each of these claims is also patentable over the art of record for at least the reasons set forth above with respect to claim 40 and with respect to intermediate dependent claim 41. Moreover, it is submitted that Flowerdew lends nothing to the rejections of claims 40 and 41, discussed above, in any reasonable combination with the remaining art of record. Further, each of these dependent claims places additional limitations on their parent and intermediate claims which, when considered in light of claim 40, further distinguish the claimed invention from the art of record.

For example, claim 42 requires that the detectors include tilt sensors for measuring the tilt angles of each detector such that the tilt angles of each detector form part of the certain information. These limitations have been discussed above with respect to claim 26. Further, it is considered that the arguments made with respect to the patentability of claim 26 over the art of record are equally applicable with respect to the patentability of claim 42. Accordingly, allowance of claim 42 is respectfully requested for at least these reasons.

Claim 43 depends directly from claim 42 and recites moving one of the detectors to a new, unknown location while the other detector remains in its initial, known position. The relative locating signal is transmitted to establish the new location of the moved detector relative to the other detector so as to also establish the absolute position of the moved detector in the region. As discussed above, Applicant finds no reasonable teaching, disclosure or suggestion of a relative locating signal, as claimed. For at least this reason, allowance of claim 43 is respectfully requested.

Claim 44 depends directly from claim 43 and further requires that the moved detector is at least initially out of range of the electromagnetic locating signal at its new location such that a predetermined amount of additional advance

of the boring tool causes the moved detector and the other detector to both be in range of said electromagnetic locating signal. Claim 45 still further requires that the new location of the moved detector is established in proximity to an anticipated drilling path of the boring tool. It should be appreciated that these features provide for extension of drilling range in a way which is impractical, if not impossible, in vertical drilling applications such as taught by Waters. Applicants are unable to find any reasonable disclosure, teaching or suggestion of these features in the art of record.

Claim 46 depends directly from claim 44 and recites that the moved detector was out of range of the electromagnetic locating signal, prior to being moved from its initial position, as a result of advance of the boring tool and wherein the moved detector is within range of the electromagnetic locating signal, after being moved, such that the moved detector remains within range of the boring tool over a subsequent advance of the boring tool. These features, again are related to extending drilling range and are submitted to be absent from the art of record when taken in any reasonable combination.

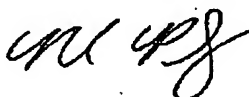
Claim 47 also depends from claim 44 and recites that sufficient additional advance of the boring tool along the anticipated drilling path causes the other detector to be out of range of the electromagnetic locating signal while the moved detector is in range and, thereafter, the other detector is moved to an advance location farther from the boring tool, but still in proximity to the anticipated drilling path. The relative locating signal is then transmitted for use in establishing the advance location of the other detector relative to the moved detector so as to also establish the absolute position of the other detector at the advance position in the region such that both detectors are again within range of the boring tool to receive the electromagnetic locating signal over further advance of the boring tool. The drilling range is thereby extended in a highly advantageous way while using only two detectors.

New claim 71 has been added which requires that the relative locating signal and the locating signal from the boring tool are dipole fields and is believed to be allowable over the art of record.

For all of the foregoing reasons, it is respectfully submitted that all of the Examiner's objections have been overcome and that the application is in condition for allowance. Hence, Applicant respectfully requests allowance of the claims under immediate consideration, and passage to issue of the application is solicited.

If the Examiner has any questions concerning this case, the Examiner is respectfully requested to contact Mike Pritzkau at 303-410-9254.

Respectfully submitted,



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